HIRDLS

HIGH RESOLUTION DYNAMICS LIMB SOUNDER

Originators Joanne Loh Date: 99-08-03

Subject / Title: **Responses to Critical Design Review RFA's**

Contents / Description / Summary:

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Key Words:

Purpose (20 characters maximum):

Approved / Reviewed By:

Date (yy–mm–dd):

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Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action **Number: 1**

Originator: Greg Greer
Phone: 301-286-7295
Organization: NASA/GSFC/545

Assigned to: L. Osborne
RO: LMMS
Due Date: Plan by 99-06-18

Category: THERMAL
Title:
Date Closed:
Residual Risk:

Action Requested:
Please rework and resubmit the response to PDR RFA #014 which asks that 'the Project should evaluate the 'open cavity' electronics enclosure [for IPS & PSS boxes] thermal design for effect of solar entrapment.'

Supporting Rationale:
The given response [TC-LOC-312] addresses the nominal survival attitude with -X pointed solar inertial and not the off-nominal case of 4HRS with (worst case) arbitrary solar pointing on the +Y side into the cavity. Note: TC-LOC-312 could (in my view) use additional information and s/b reissued. Namely: (1) Temp limits for all parts (add the limits for mirrors, chopper, lenses, displacer, etc. not included). (2) H+R power estimated for turn-on temp limits plus margin, which will increase the estimated power required. (The given analysis calculated Heater Power for achieving the exact turn-on temp, without margin, and provides an unrealistic minimum power expectation.)

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 2

Originator: Greg Greer
Phone: 301-286-7295
Organization: NASA/GSFC/545

Assigned to: I.Stewart
RO: MMS
Due Date: Plan by 99-06-18

Category: THERMAL
Title:
Date Closed:
Residual Risk:

Action Requested:
Provide detailed material evaluation data for bare graphite epoxy deterioration (if any) in direct sun exposure case.

Supporting Rationale:
Survival pointing is not exactly -X solar inertial but has some 'I' off-axis component that can put continuous glancing sun on the bare graphite for extended periods. Also, durability of materials is required in the 4 hour off axis random attitude case which could put full sun on the bare surfaces.

Project Response:
The HIRDLS panels are manufactured from M55J/RS3 laminates. RS3 is a cyanate ester resin which was first qualified on the Inmarsat 3 programme and subsequently used on Worldstar and Skynet reflectors. The Worldstar and Inmarsat reflectors were both unpainted.

This laminate system has been qualified for use over a temperature range of -100°C to +100°C.

Ref Doc:- "Data for the Selection of Materials" ESA PSS-01-701 Issue 1 Rev.3 1994

Project:	Earth Observing System
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Request for Action

Number: 3

Originator: Greg Greer
Phone: 301-286-7295
Organization: NASA/GSFC/545

Assigned to: N. Martin
RO: GSFC
Due Date:

Category: THERMAL
Title:
Date Closed:
Residual Risk:

Action Requested:
Urge TRW to provide HIRDLS with more 'TCS-user friendly' backload data separated into UV + IR component fluxes, instead of lumped together.

Supporting Rationale:
Previous programs and current experience shows that TCS analysis flexibility and responsiveness to redesign issues is greatly enhanced by separate UV/IR backloads. Such responsiveness is more highly valued in programs with tight schedules such as HIRDLS.

Project Response:

Project:	Earth Observing System
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Request for Action

Number: 4

Originator: Leroy Sparr, Steve Castles, Steve Scott
Phone: 301-286-3811, 301-286-5405, 301-286-2846
Organization: NASA/GSFC/730, NASA/GSFC/552, NASA/GSFC/730

Assigned to: B. Costanzo
RO: LMMS
Due Date: 99-06-18

Category: SCHEDULE
Title:
Date Closed:
Residual Risk:

Action Requested:
Evaluate having Ball build a structural/thermal fixture for functional and qualification testing of the cooler cold link. This fixture should include a high fidelity mock-up of the outer shell of the cooler cold finger, the snubber for the cold finger and the housing for the cold link.

Supporting Rationale:
The design of the cooler cold link is in flux. To prevent the development and testing of the cold link from impacting the schedule, the cold link testing and the cooler test program need to be de-coupled. Then the cooler can proceed through thermal vacuum test (with the radiator and a thermal, non-structural mock-up of the cold link) and, preferably, a DITS alignment test. The cooler could then be delivered to Lockheed while the cold link is developed and tested.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
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Request for Action

Number: 5

Originator: Steve Castles
Phone: 301-286-5405
Organization: NASA/GSFC/552

Assigned to: S. Richard
RO: LMMS
Due Date: 99-06-18

Category: THERMAL
Title:
Date Closed:
Residual Risk:

Action Requested:
Evaluate maintaining the flight cryocooler configuration identical to the EM cooler instead of changing the transfer line diameter and displacer stroke.

Supporting Rationale:
Changes to the cooler (as opposed to the cold link) can have complex effects that are difficult to predict. Ball has proposed changes to the flight cooler, rarely increasing the diameter of the transfer line and changing the stroke of the displacer. While these changes are probably benign, the purpose of the change is to decrease the cooler input power by only 3 watts. The EOS Chem Project should consider this trade-off carefully. It may be advisable to maintain the EM cooler heritage to reduce risk.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

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Request for Action **Number: 6**

Originator: Steve Castles
Phone: 301-286-5405
Organization: NASA/gsfc/552

Assigned to: S. Meyer
RO: LMMS
Due Date: 99-06-30

Category: CONTAMINATION
Title:
Date Closed:
Residual Risk:

Action Requested:
An analysis should be performed on the outgassing from the optical bench isolators to ensure that the outgassing will not produce unacceptable molecular contamination of the optical bench and adjacent hardware. The analysis should include test results from witness samples used during the bake-out of the silicone used in the vibration isolators. An inspection of the witness samples should be performed to determine the composition of the outgassing.

Supporting Rationale:
The optical bench vibration isolators contain a large quantity of silicone with a large outgassing half-life. It was stated during the presentation that an initial bake-out will be performed on the isolators. It was also implied that additional bake-outs will occur during subsequent levels of assembly. Part of the concern is that during subsequent bake-outs, outgassing products from the silicone may be deposited on other elements on or around the optical bench.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

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Request for Action

Number: 7

Originator: Steve Castles
Phone: 301-286-5405
Organization: NASA/GSFC/552

Assigned to: S. Meyer
RO: LMMS
Due Date: 99-06-30

Category: CONTAMINATION
Title:
Date Closed:
Residual Risk:

Action Requested:
All vents on MLI blankets that are vented inside the instrument enclosure (the STH) should be filtered. (Goddard uses a filter cloth.) To allow rapid outgassing of the blanket on orbit, large vents should be used.

Supporting Rationale:
It was stated during the presentation that the MLI blankets are vented away from optical surfaces. However, the blankets that thermally isolate the optical bench and adjacent elements would appear to vent to the interior of the STH. In principle, particles inside the STH could migrate to optical surfaces by, for example, air currents during pump down and back fill for vacuum tests; vibration during environmental tests; or via electrostatic forces.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

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Request for Action

Number: 8

Originator: Ray Turner
Phone: (44) 1235 446433
Organization: RAL

Assigned to: J. Whitney
RO: OXF
Due Date: 99-06-18

Category: OPERATIONS
Title:
Date Closed:
Residual Risk:

Action Requested:
Operations-Post Launch: Please clarify the organization and planning for immediate post launch activities (say 0 to +14 days). (1) will a HIRDLS team be co-located with the spacecraft operations team? (2) When is it planned to open aperture doors and function mechanisms? (3) When is it planned to turn on detectors? (4) What attitude requirements need to be passed to the spacecraft controllers?

Supporting Rationale:
Provision for real-time troubleshooting turn on sequence and timeline-thermal/power/contamination planning.

Project Response:
The activities covered by this RFA begin in almost 4 years time, if not later. No detailed plans have yet been documented, although some aspects are included in the Flight Operations Concept Document (OP-HIR-167) which was submitted by Oxford as a pre-CDR CDRL. It can safely be assumed that the details will be based on - and similar to - the corresponding activities performed at ISAMS launch in 1991, especially now that NASA have indicated that the Flight Ops environment will be virtually the same as for UARS. The details listed in this RFA will probably be documented as part of, or in parallel with, the next phase of Instrument Activation planning which is scheduled for early 2000.

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Request for Action **Number: 9**

Originator: Ray Turner
Phone: (44) 1235 446433
Organization: RAL

Assigned to: I. Stewart
RO: MMS
Due Date: 99-06-18

Category: MECHANISMS
Title:
Date Closed:
Residual Risk:

Action Requested:
SSH Deployment Mechanism-Please confirm assumption that the brake is a magnetic detent type (i.e., non-contacting).

Supporting Rationale:
(1) Details not available at CDR. (2) Characteristics of a contacting brake would be uncertain.

Project Response:
The SSH uses a non-contacting magnetic brake on the motor/hinge axis rotating at the same speed as the motor. The brake thus operates when the motor is stationary and holds the SSH door in position supplementing the motor detent.

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Request for Action **Number: 10**

Originator: Ray Turner
Phone: (44) 1235 446433
Organization: RAL

Assigned to: I. Stewart
RO: MMS
Due Date: 99-06-18

Category: MECHANISMS
Title:
Date Closed:
Residual Risk:

Action Requested:
SVA Door-The mechanism drives into stops. Verify that enough torque is available to drive out of any resulting 'lock' in the system.

Supporting Rationale:
It is possible to drive a worm and gear into a 'taper' lock situation (i.e., not load reversible and friction exists). Usually the torque available for release is the same as used to drive into the stop. This may not be enough to overcome friction?

Project Response:
The higher torque requirement to drive OUT was addressed in the initial (and final) design of the SVA. (Drive out must be > Drive In).

This could be achieved by two methods. The second of which was not incorporated after EM Qualification tests showed it was not needed.

a) Use of a large and small diameter as outlined below.

    (i) The SVA is driven CLOSED at 28V on a large diameter that is not lubricated.

    (ii)The SVA is driven open on a smaller diameter that is lubricated.

    (iii) The diameter change is 2:1. The friction difference is 0.3 (non-lubricated Al/steel interface) and 0.1 (lubricated).

    (iv) The result is that in theory 1/6 of the torque to close is required to open the door. In fact by starting from stationary (no momentum available) the figure is closer to 1/3 of the torque. Still a healthy margin to ensure the door opens.

b) Use of a resistor and diode in parallel to permit higher voltage for drive OPEN.

In the EM tests the theory was demonstrated by driving the door closed into the stall condition at 28V. The door was then opened by reducing the voltage to 3V and slowly increasing voltage until the door was driven out of the lock. The door opened at 8V on the test prior to delivery both under ambient and vacuum conditions.

The motor drive torque is directly proportional to winding current and the effect of reducing the voltage also reduces the available winding current. Thus the ratio of available voltage/minimum operating voltage demonstrates the torque margin (or torque ratio).

A further note was made that the Torque Margin is quoted in documentation, this in fact was correctly identified by one of the CDR review team as being a Torque Ratio (as defined in MAR). This is not a problem with mechanisms (with structures Stress Margin of Safety and Stress Reserve Factor are different) but seems to be a common slip in terminology used by the Mechanisms community.

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Request for Action

Number: 11

Originator: Gary Brown, Ray Turner
Phone: 301-286-1304, (44) 1235 446433
Organization: NASA/GSFC/544, RAL

Assigned to: Opyd/Rudolf
RO: LMMS
Due Date: 99-06-18

Category: MECHANISMS
Title:
Date Closed:
Residual Risk:

Action Requested:
Chopper- 1) Evaluate running a PFM chopper system at 5000 RPM for an extended period (monitoring bearing noise if possible)? 2) Produce a detailed failure analysis and report of the reported bearing failure..

Supporting Rationale:
The well planned accelerated tests are not quite the same build and some tests are at 2x nominal speed. The oil film bearings just may throw up small problems under different hydrodynamic conditions-so an accelerated test may not be appropriate. (Tests in 1g with oil bearings are a problem unless dominated by capillary action.) The failure of the bearing in the life test is alarming. The fact that one bearing was virtually destroyed during a test that only included nominal temperature operation requires further test, analysis, and redesign considerations. These events are very recent, but action needs to be taken quickly.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

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Request for Action

Number: 12

Originator: Ray Turner
Phone: (44) 1235 446433
Organization: RAL

Assigned to: Dials/Arter
RO: UCB
Due Date: 99-06-30

Category: MASS
Title:
Date Closed:
Residual Risk:

Action Requested:
Instrument structure qualification-potential mismatch with unit masses and c.g. positions. (1) Please would the project conduct a post CDR audit to log the frozen unit masses and C of G positions and to identify those which are not yet considered firm? (2) Please would the project assess the structural implications and decide which increases/changes can be allowed? (3) Please would the project assess the merits of continued mass reduction exercises in respect of schedule and structural response?

Supporting Rationale:
As presented at the CDR viewfoil STH-8 indicated that concerns for electronic box mass and C of G had been 'retired,' but when a later presentation discussed mass of the PSS unit-it was then revealed that these were structural concerns over a possible 1kg increase in mass. There may be other conflicts which were not discussed. In many areas schedule is very tight. Relaxation in mass redistribution for the instrument as a whole may assist some critical schedules.

Project Response:
See response to RFA #47.

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Request for Action **Number: 13**

Originator: Ray Turner
Phone: (44) 1235 446433
Organization: RAL

Assigned to: N. Morris
RO: RAL
Due Date: Plan by 99-06-18

Category: THERMAL
Title:
Date Closed:
Residual Risk:

Action Requested:
PSS-Thermal. Provide results of updated thermal model and analysis for the PSS after redesign is complete.

Supporting Rationale:
The PSS internal architecture is undergoing radical redesign with high power components being relocated.

Project Response:
Now that the layout of the PFM PSS has been finalised, it will be possible to update the thermal model of the PFM PSS. This will be completed by 23 July 1999.

Nigel Morris

18 June 1999

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
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Request for Action

Number: 14

Originator: Ray Turner
Phone: (44) 1235 446433
Organization: RAL

Assigned to: F. Adams
RO: LMMS
Due Date: 99-08-20

Category: RADIATION
Title:
Date Closed:
Residual Risk:

Action Requested:
S.A.A-Asses the potential effects caused by the South Atlantic anomaly specifically on detector systems.

Supporting Rationale:

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

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Request for Action

Number: 15

Originator: Paul Brook
Phone: (44) 1252 393267
Organization: NERC

Assigned to: J. Whitney
RO: OXF
Due Date: 99-06-18

Category: ATTITUDE CONTROL
Title:
Date Closed:
Residual Risk:

Action Requested: There was a confusion over the requirement on the GSS to maintain a 1-4' accuracy between orbits (post de-trending). This needs to be clarified and the capability of external references in supporting such LOS accuracy critically assessed (tropical atmospheric features for linear correction of gyro drift).

Supporting Rationale:

Project Response:
First the extent of the information derived from the temperature/pressure retrieval algorithm needs to be understood:

Gille and House (`On the Inversion of Limb Radiance Measurements, I, Temperature and Thickness', J.Atmos.Sci., 28, 1427-1442 (1971)) showed that measurements of the vertical profiles of limb infrared emission from a gas of known mixing ratio (CO_2 in this case) at two or more wavelengths with differing vertical opacity gradients are sufficient for temperature to be determined as a function of pressure. This was subsequently demonstrated by instruments on the Nimbus and UARS satellites.

It is only necessary to know the relative, not absolute, tangent heights (or absolute elevation angles) of the radiance measurements to high accuracy to obtain useful single profile retrievals.

The HIRDLS Level-2 retrieval algorithm will produce this information, i.e. temperature and pressure on this relative height or elevation angle scale.

The Gyroscope Subsystem is provided to improve relative point knowledge within individual profiles in order to make the above retrieval process viable, and also to enable the height scales of adjacent profiles to be interrelated so that horizontal gradients of pressure at a given height (or height at a given pressure) may be obtained. Such gradients are important scientifically because they are directly related to wind velocity, which affects the mixing and transport of trace gases, and also to potential vorticity which is a dynamical quantity that is approximately conserved, hence acts as a tracer.

The stated aim is to process the HIRDLS science data on the ground to achieve a relative error elevation error between adjacent temperature/pressure retrievals of 1.4 arcsec rms or less. This angle corresponds to 20 metres height at the tangent point.

This applies between adjacent profiles measured within the scan pattern, for which the temporal spacing is either about 10 seconds (for cross-track separation) or about 66 seconds (for along-track spacing).

The scanning sequence will be arranged so that successive orbit swaths either:

a) Just touch (so that the line of profiles at one end of the swath on one orbit follows the line of profiles at the other of the swath on the previous or following orbit); this will be the case in the tropics where the azimuth scan range is deliberatly chosen to be sufficient, with margin. We may choose to use a smaller scan range away from the tropics so that the orbits just touch touch there as well.

b) Overlap (so that profiles from one orbit fall inside the swath of an adjacent orbit).

The data processing will exploit the duplicate coverage in order to fit the gyro drift rates in pitch and roll (yaw is less critical, and will need to be fitted by normalising in the mean to the spacecraft yaw measurements). In its simplest form the processing would not use external data (other than the spacecraft yaw) and would use an assumption of closure, integrating geopotential height around the Earth, particularly at low latitudes where horizontal gradients are small. In its ideal form, an optimal combination would be performed with an a-priori constant pressure analysis field (e.g. from a forecasting agency) to exploit the broad-scale knowledge contained in the analysis field, particularly in stable areas, and the high spatial resolution HIRDLS data.

The latter involves certain assumptions:

a) that the large scale atmospheric changes over the orbit return time (approximately 100 minutes) are small and random;

b) either that the atmosphere is horizontally stratified (this is quite a good assumption to adequate accuracy in the tropics); or that a constant pressure altitude field is available from a weather forecasting agency that includes areas visited by the satellite each orbit (e.g. the tropics) where the large-scale features are known.

Regarding (a), the large scale structures appear to change by just a few metres in the tropics over 100 minutes, so this is not a problem. There have been suggestions that the solar tides might introduce consistent errors. An extensive body of literature exists to describe tidal theory extending back to Laplace, Hough and more recently Lindzen, and some of the HIRDLS co-investigators have been involved in this work. It is currently believed that the tidal amplitudes in the low stratosphere are sufficiently small as to have a negligible effect over the 100 minutes local time change relevant here. Furthermore the analysis will inherently eliminate any tidal component, which is desirable for many data applications, provided that the horizontal spatial scale of the tide is large (i.e. near global) and the structure zonally symmetric. Theory predicts this to be the case, and observations are consistent.

Regarding (b), meteorological agencies currently produce the required data fields operationally at least twice per day, and there is no reason to believe that this will cease. The height gradients (which are what are required) should be sufficiently accurate at low latitudes and away from winter-time stratosphere perturbations. Ideally error fields would be available, so that the the HIRDLS data may be fitted optimally, and there is some possibility that these will be provided operationally by the time of the HIRDLS launch. [JJB]

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Request for Action

Number: 16

Originator: Gary Brown
Phone: 301-286-1304
Organization: NASA/GSFC/544

Assigned to: A. Carrier
RO: LMMS
Due Date: 99-06-18

Category: MECHANISMS
Title:
Date Closed:
Residual Risk:

Action Requested:
Provide some test results on azimuth performance testing. What are gain and phase margins on elevation, azimuth, and chopper control loops? How will they be verified?

Supporting Rationale:
Verify robust control system design.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

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Request for Action **Number: 17**

Originator: Gary Brown
Phone: 301-286-1304
Organization: NASA/GSFC/544

Assigned to: P. Dean
RO: LMMS
Due Date: Plan by 99-06-18

Category: MECHANISMS
Title:
Date Closed:
Residual Risk:

Action Requested:
Increase torque margin to provide >3 times BOL friction torques plus 1.25 times inertial and spring loads. From a splinter meeting with GSFC and LMMS personnel, the following options need to be looked at: (1) Reduce bearing preload-analyze impacts to launch loads, 1st mode stiffness, control loop performance, and LOS pointing errors. (2) Detailed thermal analysis to determine worst case operating temperatures and potential gradients across the bearings. (3) Test flight-like bearings drag friction over full temperature range. (4) Consider drive circuit changes to provide more voltage across windings.

Supporting Rationale:
The present prediction of

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

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Request for Action **Number: 18**

Originator: Ed Bielecki
Phone: 301-286-7251
Organization: Boeing/GSFC/424

Assigned to: J. Whitney
RO: OXF
Due Date: 99-06-18

Category: C&DH
Title:
Date Closed:
Residual Risk:

Action Requested:
Consider automating the determination of the Synchronous Detection parameter used for each detector channel in the SPU. Recommend implementing this scheme for re-verifying proper synchronization as part of an in-flight calibration procedure or by ground command.

Supporting Rationale:
Phase shift in each analog processing channel is a function of temperature, component aging, component failure, etc. Relying on pre-flight determination of sync parameters for the entire mission life appears to be overly optimistic. It can't hurt to double-check parameters; might also prove to be invaluable as a diagnostic during calibration of instrument at Oxford.

Project Response:
It is not true that we are relying on subsystem measurements of detector channel sync. It is planned to perform routines which cycle through a range of settings for all channels to determine the optimal values during instrument calibration. We did this both pe-launch and in orbit for the UARS/ISAMS instrument and we also plan to do it for HIRDLS, for exactly the reasons stated in the RFA.

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Request for Action

Number: 19

Originator: Leroy Sparr
Phone: 301-286-3811
Organization: NASA/GSFC/730

Assigned to: B. Costanzo
RO: LMMS
Due Date: 99-06-18

Category: MECHANICAL
Title:
Date Closed:
Residual Risk:

Action Requested:
The CSS is hard-mounted to STH and the DSS is hard-mounted to OBA which is on flexible mount to STH. Therefore, rotation about CSS/DSS interface is likely. It is currently not addressed in EDM design. LMATC must provide displacement/rotation data to Ball and a mutually agreeable fix must be implemented.

Supporting Rationale:
Current EM CSS/DSS design is very stiff to rotational displacements and damage could result from system level vibration testing if not addressed.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

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Request for Action **Number: 20**

Originator: Philip Chen
Phone: 301-286-8651
Organization: NASA/GSFC/545

Assigned to: S. Meyer
RO: LMMS
Due Date: 99-06-30

Category: CONTAMINATION
Title:
Date Closed:
Residual Risk:

Action Requested:
There are many organizations involved in the HIRDLS instrument buildup. Each organization may or may not have an engineer assigned to the contamination area. In addition, there is no normal communication channel for design information exchange. In order to meet EOL science requirements, proper cleanliness levels need to be maintained. Each organization needs to identify a point-of-contact. One organization needs to assume an overall responsibility for coordinating the contamination effort. A channel is needed to review contamination budgets, documents, analyses, testing, and I&T processes.

Supporting Rationale:
Contamination may become a design, process, and therefore cost driver if we don't pay enough attention at this stage. Currently the contamination effort is behind a normal CDR level.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

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Request for Action

Number: 21

Originator: Dennis Dillman
Phone: 301-286-7237
Organization: NASA/GSFC/301

Assigned to: G. Inouye
RO: LMMS
Due Date: 99-06-18

Category: RELIABILITY
Title:
Date Closed:
Residual Risk:

Action Requested:
(1) Clarify the assumptions used in the 'Commercial Satellite Operational Environment' quoted in the reliability analysis (e.g., orbit altitude, inclination). (2) Provide rationale why this is the most appropriate environment model for HIRDLS (vs. other options like 'military').

Supporting Rationale:
Reliability analyses are heavily dependent upon the quality of the assumptions used. It was not clear that the 'Commercial Satellite Operational Environment' actually reflected the EOS-CHEM orbital environment.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 22

Originator: Steve Scott
Phone: 301-286-2846
Organization: NASA/GSFC/730

Assigned to: W. Rudolf
RO: LMMS
Due Date: 99-07-11

Category: OPTICS
Title:
Date Closed:
Residual Risk:

Action Requested:
Describe the measures taken to ensure that Ultraviolet (UV) Solar Radiation (small wavelength radiation) will not leak into the optics of the instrument, thereby heating the instrument and crosslinking contaminants on optical or other surfaces.

Supporting Rationale:
UV could enter gaps and heat or damage optics or detectors.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action **Number: 23**

Originator: Steve Scott
Phone: 301-286-2846
Organization: NASA/GSFC/730

Assigned to: R. Howard
RO: UCB
Due Date: 99-06-18

Category: PRODUCT ASSURANCE
Title:
Date Closed:
Residual Risk:

Action Requested:
Describe the Problem Reporting and Corrective Action processes during Instrument Integration, during Satellite I&T, at the launch site, and during the post-launch on-orbit checkout and verification period. Under whose Problem Reporting and Configuration Management System will the HIRDLS instrument be governed at each stage?

Supporting Rationale:
There did not seem to be a plan for providing/integrating Instrument Problem Reporting at these crucial project intervals.

Project Response:
Instrument integration will be done at LOC & discrepancies involving flight hardware or software will be governed by HIRDLS Instrument Integration Performance Assurance Implementation Plan, PA-LOC-072. This Plan is based upon the requirements set forth in the Mission Assurance Requirements for HIRDLS (MAR), GSFC 424-11-13-01 and supplemented by Lockheed internal procedures and requirements. The LOC Material Review Board (MRB) would request any needed support for the troubleshooting &/or repair from the applicable RO. Corrective action activity is also under the control of MRB.

The University of Colorado, Boulder is a member of the MRB for all activity that involves test failure &/or repairs to flight hardware or software.

As satellite I&T and launch site operations are after the instrument has been delivered to NASA/Goddard & no longer under the direct control of UCB, the problem reporting & corrective action for all activities after delivery for satellite integration will follow Standard Operating Procedures that belong to the Integrator, TRW.

My expectation is that TRW will initiate a Discrepancy Report (or TRW equivalent) to begin the process of anomaly identification and resolution. If a discrepancy involves HIRDLS hardware, GSE or software, the TRW MRB would request the assistance of the appropriate personnel from the HIRDLS program.

I would also expect that NASA/Goddard would be a member of the MRB & have total oversight of all activities of this nature.

Under TRW MRB control, troubleshooting, repair and corrective action processes will be used to bring the HIRDLS supplied product into operational &/or procedural compliance.

Discrepancies post-launch will follow a similar methodology that would be controlled by Goddard Flight Operations.

Configuration Management.

Configuration management will be maintained throughout all these operations as required by the appropriate MRB.

In general terms if during Instrument Integration drawings &/or documents need to be revised to implement MRB direction, the HIRDLS Configuration Management Plan, PM-HIR-004, specifically allows redline implementation for changes of this nature. The redlines would become a part of the End Item Data Package for Instrument Integration.

Post delivery activities would rely on the TRW MRB and Goddard Flight Operations to use similar controls to maintain configuration control with NASA/Goddard oversight.

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action **Number: 24**

Originator: Steve Scott
Phone: 301-286-2846
Organization: NASA/GSFC/730

Assigned to: J. Drake
RO: LMMS
Due Date: 99-06-18

Category: SOFTWARE
Title:
Date Closed:
Residual Risk:

Action Requested:
Develop a realistic CPU throughput worst case test.

Supporting Rationale:
It is not clear the worst case CPU throughput peak has been determined or tested.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action **Number: 25**

Originator: Steve Scott
Phone: 301-286-2846
Organization: NASA/GSFC/730

Assigned to: J. Whitney
RO: OXF
Due Date: 99-06-30

Category: SOFTWARE
Title:
Date Closed:
Residual Risk:

Action Requested:
Describe/document the instrument failure detection and correction software. What is the instrument failure detection and correction software designed to do (e.g., 'safe' the instrument or switch redundant components)?

Supporting Rationale:
It is not clear if the fault management software philosophy or design has been thought out. This is an instrument systems engineering job-not just a software job.

Project Response:
The Instrument Fault management philosophy is indeed being thought out. The HIRDLS System Engineer is aware that it is a system engineering function. An initial set of autonomous fault detection items and corresponding corrective actions was documented in August 1997 (see TC-LOC-212) and was covered at the HIRDLS PDR. Since then, in order to reduce costs, the autonomous FD&C criteria have been revisited to make them more selective. This topic is the subject of a systems-software meeting to be held at LMMS at the end of June. The revised FD&C table will be included in the HIRDLS Command & Telemetry Handbook, Section 4 (Table 4.3-1).

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: **26**

Originator: Steve Scott
Phone: 301-286-2846
Organization: NASA/GSFC/730

Assigned to: J. Drake
RO: LMMS
Due Date: 99-06-18

Category: SOFTWARE
Title:
Date Closed:
Residual Risk:

Action Requested:
The software to reset the Watch Dog Timer should be the lowest priority task. Discuss how the software will be 'safe' if the WDT allows the software and OS to run despite problems or crashes in the application software. How do you detect the problem of software tasks not completing within a required processing cycle?

Supporting Rationale:
If the WDT reset is a high priority task then other, lower-priority tasks may not run to completion, yet the WDT will still be set. It seems potentially dangerous to allow the OS to run when tasks are not completing. We need an explanation on how the software detects tasks not completing or never getting executed, especially since command is not the highest priority task.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action **Number: 27**

Originator: Bob Martineau
Phone: 301-286-9479
Organization: NASA/GSFC/553

Assigned to: F. Adams
RO: LMMS
Due Date: Plan by 99-06-18

Category: DETECTORS
Title:
Date Closed:
Residual Risk:

Action Requested:
Complete a compliance matrix for all DSS specifications, not just a subset of the important specifications.

Supporting Rationale:
Assures oversight and review of all specifications and documents status.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 28

Originator: Bob Martineau
Phone: 301-286-9479
Organization: NASA/GSFC/553

Assigned to: F. Adams
RO: LMMS
Due Date: 99-08-31

Category: DETECTORS
Title:
Date Closed:
Residual Risk:

Action Requested:
Perform and document optical crosstalk tests and measurements as soon as possible.

Supporting Rationale:
Determine if there exists a crosstalk problem with the cut-filter, cold filter assembly (CFA) design before PFM build.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action **Number: 29**

Originator: Bob Martineau
Phone: 301-286-9479
Organization: NASA/GSFC/553

Assigned to: F. Adams
RO: LMMS
Due Date: Plan by 99-06-18

Category: DETECTORS
Title:
Date Closed:
Residual Risk:

Action Requested:
Perform vibration test on CFA (cold filter assembly) mockup before using design on PFM FPA. Consider epoxy support close to center as well as proposed support at corners.

Supporting Rationale:
Near center support will reduce/eliminate drumming vibrations. Not all modules have same height. Unless mask is properly attached, it could vibrate against a module and cause damage, or shatter. Prove out design integrity before good detectors and dewar are committed. Avoid turning a good dewar into an expensive rattle.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 30

Originator: Roger Evans
Phone: 301-286-0929
Organization: Unisys/GSFC/303

Assigned to: R. Howard
RO: UCB
Due Date: 99-06-18

Category: SOFTWARE
Title:
Date Closed:
Residual Risk:

Action Requested:
Understand that the HIRDLS S/W will still be under S/W lead CM after CDR. NASA needs to know process of CM transition from S/W lead at Ball and Lockheed after CDR.

Supporting Rationale:
It is 'normal' practice after CDR that design is under formal CM.

Project Response:
HIRDLS Flight Software Management Plan, SW-HIR-096, Paragraph 4.5, documents the software CM process. In the first paragraph, the following two points are made:

1. "The Software Requirements Documents will be placed under program configuration control at the Software Requirements Review." The software requirements documents (SW-LOC-108 and SW-LOC-110) were released formally initially on 980430. The TSW Software Requirements Document was update to Rev. B and released on 990406. Both documents and all releases were reviewed and signed off by LMMS HIRDLS Program personnel.

2. "The Software Specifications Document will be placed under program configuration control at the Critical Design Review." The Software Specifications Documents are the Software Detailed Design Documents (SW-LOC-113 and SW-LOC-115 for the IPU and TEU respectively). These documents were produced in draft form for the CDR. It is planned that they be formally released 60 days after CDR (end of June). The SAIL Detailed Design Document is SW-LOC-180. This document is under development and at least a draft can also be released at the end of June.

The HIRDLS Flight Software Management Plan, SW-HIR-096 has been flowed down to all ROs and will be followed for S/W configuration management after CDR. UCB, Oxford, systems engineering, subsystem engineers as necessary and LMMS program management participate in the CCB process for making changes to the software (using Software Change Request forms).

The only additional control that can be considered is code control, both source and executable. This is under control at LMMS using Revision Control System (RCS). The software developers maintain their own code control according to the Requirements and Design documentation. It has been the plan that turning the source code over to UCB and Oxford for higher level control would not occur until the end of the contract with LMMS or at least until the end of the software development (upon Software Acceptance Test completion for each CSCI).

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action **Number: 31**

Originator: Paul Brook
Phone: (44) 1252 393267
Organization: NERC

Assigned to: J. Whitney
RO: OXF
Due Date: 99-06-18

Category: RELIABILITY
Title:
Date Closed:
Residual Risk:

Action Requested:
Given the lack of requirement on system reliability, what would be the impact on the PSS mass and reliability of removing parts of the redundancy in the design to remove the current mass problem?

Supporting Rationale:
Without a firm system reliability requirement the allocation of reliability and hence redundancy seems a little 'ad-hoc.' Given the current concerns on mass across the instrument, a similar reconsideration of redundancy across the instrument may be appropriate.

Project Response:
It is true that the HIRDLS project has been forced to back down from the original goal of "85% probability of full operation for 5 years in orbit", but it is absolutely untrue that there is a "lack of requirement on system reliability". The original reliability 'allocation' of 99% for the PSS is no longer considered realistic and simplifications have recently been agreed at system level in order to reduce mass. When the tradeoff analysis has been completed by RAL, a revised reliability estimate will be available and is expected to be entirely consistent with the overall revised figure of around 75%. This may not have been clearly presented at the CDR, largely because the analysis was still in hand and various options still being considered. We do not give up easily on reliability! More generally we have on many occasions proposed and discussed removal of redundancy in some or all of our electronics*, but until now we have not been forced to proceed along this path. [* Note that only the IPU/BEU and the TEU are fully redundant. Other subsystems contain partial or no redundancy]

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 32

Originator: Paul Brook
Phone: (44) 1252 393267
Organization: NERC

Assigned to: B. Hurlbut
RO: LMMS
Due Date: 99-06-18

Category: MECHANICAL
Title:
Date Closed:
Residual Risk:

Action Requested:
Confirm that all subsystems are aware of the expected vibration levels in acceptance testing based upon the STH EM tests and analysis and that they are not relying on the GIRD levels.

Supporting Rationale:
The TSS was noted to require discussions on these levels. The IPS was noted to have no structural analysis and no EM test results for resonances that could couple with the STH transfer function.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 33

Originator: Paul Brook
Phone: (44) 1252 393267
Organization: NERC

Assigned to: J. Whitney
RO: OXF
Due Date: 99-06-18

Category: POWER
Title:
Date Closed:
Residual Risk:

Action Requested:
The IPU is noted to have independent power supplies to 'provide isolation from subsystem faults.' Propagation of faults from subsystems to other units is a system level issue. Is the project content with the fault isolation strategy across the instrument and with the implementation of further protection (with mass and power penalty) within the IPU?

Supporting Rationale:

Project Response:
This RFA appears to be based on a complete mis-description and/or misunderstanding of the position. The decision to place power converters within the IPU was endorsed by the HIRDLS System Engineer as a result of a meeting called by him at LMMS in January 1997 to discuss HIRDLS power distribution architecture. The decision was based entirely on impedance/circulating-current and system-level EMI considerations. Fault isolation issues were discussed at this meeting and were taken into account. No special features are included in the IPU power supplies purely to provide isolation from subsystem faults.

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 34

Originator: James Hendershot
Phone: 301-286-6455
Organization: Boeing/GSFC/424

Assigned to: N. Morris
RO: RAL
Due Date: Plan by 99-06-18

Category: SYSTEMS ENG.
Title:
Date Closed:
Residual Risk:

Action Requested:
(1) Update HIRDLS GLINT FOV to reflect current design (UIID update). (2) Assess impact of intrusion by TES earth shade into HIRDLS GLINT FOV. (A consolidated impact assessment which considers both HIRDLS thermal and GLINT requirements.)

Supporting Rationale:
(1) Compliance/non-compliance with GLINT FOV requirements not provided at CDR (requirements detailed in HIRDLS UIID). (2) GLINT FOV specified in HIRDLS UIID does not reflect current geometry of HIRDLS structure (GLINT FOV requirement has not been updated to reflect design changes over the past year or two). (3) Proper geometry of GLINT FOV required for identification by S/C of intrusions by other instruments into the HIRDLS GLINT FOV. (How much of TES earth shade is in the GLINT FOV?)

Project Response:
The Glint FOV analysis on the larger TES Earthshade has been completed and documented in TC-RAL-113.

Nigel Morris

18 June 1999.

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 35

Originator: Philip Chen
Phone: 301-286-8651
Organization: NASA/GSFC/545

Assigned to: Osborne/Meyer
RO: LMMS
Due Date: Plan by 99-06-18

Category: MATERIALS
Title:
Date Closed:
Residual Risk:

Action Requested:
Provide (1) background information of White Tedlar film, (2) rationale and suitability of its usage as part of the HIRDLS thermal control surfaces, and (3) procedures and method to attach White Tedlar to the structure. White Tedlar will be on +Z and -X sides of HIRDLS.

Supporting Rationale:
White Tedlar is the substitute for Z93 paint to avoid excess particle generation. However, there may not be sufficient on-orbit application data for using White Tedlar.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 36

Originator: Paul Brook
Phone: (44) 1252 393267
Organization: NERC

Assigned to: J. Whitney
RO: OXF
Due Date: 99-06-18

Category: SYSTEMS ENG.
Title:
Date Closed:
Residual Risk:

Action Requested:
A system level analysis and allocation of radiometric noise contributions is required to highlight the significant sources and ensure effort at performance enhancement is well targeted. In particular the effect of EMC (particularly the cryocooler) and inclusion of Poisson and digitization noise in the budget is required. The analysis needs to be in some consistent units (NEN?) and related to a top level requirement.

Supporting Rationale:
Many subsystems are tackling demanding performance requirements to meet noise levels: detector, stray light, electronics, thermal, jitter, calibration, etc. The dominant sources need to be tackled and low contributors can be relaxed.

Project Response:
The task described by the "Action Requested" was first carried out in 1993 and has been updated many times since then, right up to 1998. The relevant figures will be found in the INSTRNEN and OPDETPRE Budget tables which are part of the System Performance Requirements & Allocations Tables ("SPRAT" - TC-HIR-57H). These tables have been presented and discussed at several previous HIRDLS reviews. They were omitted from the CDR due to lack of time and the desire not to go over too much old ground. The SPRAT has been available to all HIRDLS-related organisations for a very long time.

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action **Number: 37**

Originator: Paul Brook
Phone: (44) 1252 393267
Organization: NERC

Assigned to: Woodard/Whitney
RO: UCB/OXF
Due Date: 99-06-30

Category: POWER
Title:
Date Closed:
Residual Risk:

Action Requested:
Review percentages of estimated, calculated, and measured power estimates to ensure 100% allocation on Lanham 16/17. (SSH HDRM, SSH Door and NB total.)

Supporting Rationale:
Figures do not add up.

Project Response:
The HIRDLS power numbers have been audited by D. Woodard since the CDR. Corrections and adjustments have been made and the HIRDLS Power Report has been revised. The latest HIRDLS power report has been released, TC-LOC-075W.

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 38

Originator: Steve Scott
Phone: 301-286-2846
Organization: NASA/GSFC/730

Assigned to: N. Martin
RO: GSFC
Due Date:

Category: SYSTEMS ENG.
Title:
Date Closed:
Residual Risk:

Action Requested:
Determine whether the gyro subsystem can be replaced or supplemented by a simple angular displacement sensor assembly (accelerometers along each axis), and whether simply passing spacecraft disturbance knowledge to the ground can enable the ground science algorithms to accommodate or correct for spacecraft jitter.

Supporting Rationale:
A simple ADS/ADA could possibly replace the gyro for the entire bandwidth of spacecraft disturbances due to jitter, wheel noise, etc. With disturbance knowledge passed to the ground, science algorithms could be modified/developed to correct for jitter with minimal impact to the spacecraft or instruments.

Project Response:

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: **39**

Originator: Steve Scott
Phone: 301-286-2846
Organization: NASA/GSFC/730

Assigned to: J. Whitney
RO: OXF
Due Date: 99-06-18

Category: OPERATIONS
Title:
Date Closed:
Residual Risk:

Action Requested:
Describe the plan for IGSE, SAIL workstation, and simulator support for HIRDLS at TRW during Integration and Testing and at the launch site. Where will the science team be during I&T, during pre-launch launch site preparations, during launch, and during post-launch operations and maintenance periods? Where did the requirement for extra operations centers come from?

Supporting Rationale:
There did not seem to be a clear plan for IGSE, SAIL workstation, and simulator support during I&T and at the launch site. It was unclear where the instrument operations and science support would be at launch and whether the right tools would be with them. It is very unclear where the requirement for a back-up UCB flights ops capability originates and whether it is needed.

Project Response:
There is a plan for IGSE, SAIL w/s, IST, etc. during S/C I&T, at the launch site prior to launch, and thereafter at each of the HIRDLS operations sites, with appropriate engineering and operational support at the EOCC for immediate post-launch activities. This plan was not presented in any detail at the CDR because the details have yet to be worked out - the period in question is still 2.5 years in the future. The SAIL w/s is part of the IEGSE; presumably the "simulator" referred to here is the Instrument Simulator which will be used to check out the SAIL routines before they are loaded into the Instrument. The Simulator implementation can be done in a number of ways; this is clearly defined as a UK task and is still under discussion; however, it is certainly intended that an Instrument Simulator be either part of - or shipped with - the IEGSE.

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 40

Originator: Steve Scott
Phone: 301-286-2846
Organization: NASA/GSFC/730

Assigned to: J. Whitney
RO: OXF
Due Date: 99-06-18

Category: OPERATIONS
Title:
Date Closed:
Residual Risk:

Action Requested:
Co-locate a SAIL compiler workstation and simulator for testing SAIL microloads in the EOS-CHEM Operations Center. Provide a communications plan describing how SAIL microloads, new STOL procedures, software patches, etc. will be transferred securely and without error to the EOS-CHEM Operations Center. Determine the protocols for transferring command requests from the instrument scientists to operations.

Supporting Rationale:
It is not clear where SAIL microloads will be composed post-launch, long-term. There is no communications plan between the widely-geographically-separated science and operations groups.

Project Response:
Everything recommended in this RFA obviously needs to be addressed. This will be done when the detailed operations planning for HIRDLS is carried out some time during next year. It is likely that the implementation of these activities and arrangements will be similar to their successful implementation on the UARS/ISAMS program.

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 41

Originator: Steve Scott
Phone: 301-286-2846
Organization: NASA/GSFC/730

Assigned to: Gille/Barnett
RO: UCB/OXF
Due Date: 99-06-30

Category: SYSTEMS ENG.
Title:
Date Closed:
Residual Risk:

Action Requested:
Describe the specific impacts to HIRDLS Level 1 Science requirements from disturbances due to spacecraft jitter. Enumerate completely and in detail the specific impacts to Level 1 Science requirements (not vague concerns).

Supporting Rationale:
The EOS-CHEM Project must determine the instrument and system-level impacts of spacecraft jitter. In order to do so, it must know the specific impacts to each instrument.

Project Response:

The HIRDLS instrument is designed to measure the global distribution of temperature and constituent distributions of O_3, H_2O, CH_4, N_2O, NO_2, HNO_3, N_2O_5, CFC-11, CFC-12, $ClONO_2$, and aerosols in the upper troposphere, stratosphere, and mesosphere. The overall science goals for the HIRDLS instrument are focussed on increasing our understanding of upper troposphere to mesospheric chemistry and dynamical processes. Generally, these include derivation of fluxes of mass and chemical constituents between the troposphere and stratosphere; the momentum, energy, heat, and potential vorticity balances of the upper troposphere and middle atmosphere; long term climatologies and interannual variability of middle atmosphere temperature, constituents, dynamical fields, and gravity waves; and diagnostic studies of atmospheric dynamics, chemistry, and transport processes.

The success of the above mentioned science goals is dependent on the HIRDLS instrument to retrieve high-resolution radiance data with high accuracy and precision. Several factors will be discussed that contribute to the increase in random error that will affect these goals.

Estimates of the random error in the concentrations of chemical constituents derived from HIRDLS observations have been made by the HIRDLS science team. The contributors to these errors are radiometric noise, instrument line-of-sight pointing error (frequencies < 36 Hz), and estimation of line-of-sight “jitter” (frequencies > 36 Hz) due to imported spacecraft (S/C) vibrational disturbances. LOS jitter due to disturbance sources internal to the HIRDLS instrument is expected to be small. HIRDLS LOS jitter levels based upon a current estimate of spacecraft disturbance levels and upon a factor of 2 increase above this estimate were considered. The factor of 2 higher LOS jitter level is a reasonable estimate bounding the uncertainty in the magnitude of the spacecraft disturbance prediction.

Jitter is most important where the radiance profile has large curvature, since the interactions of the line of sight motions with the curvature can generate sum and difference signals within the signal pass-band (< 36 Hz). (Motions within the 36 Hz band are measured by the gyro, and can be corrected.) Large curvature is found near the tropopause and in the upper troposphere (~ 7-16 km) for most of the HIRDLS spectral channels.

Of the HIRDLS gases, N_2O_5 and $ClONO_2$ are primarily present in layers in the stratosphere, and are present in very small quantities near the tropopause, and thus not affected. NO_2 is also present in a stratospheric layer, but is present down into the troposphere. However, because of the opacity of O_2 pressure induced absorption, it will not be observable below about 18 km. On the other hand, CH_4 and N_2O are well-mixed and nearly uniform with altitude in the troposphere and low stratosphere, so observation of the variation of their mixing ratios is not crucial in this region of the atmosphere. The same can nearly be said of CFC12.

The impacts of these components of the overall random error will therefore be discussed for O_3, H_2O, HNO_3, and CFC11. Of these, O_3 and HNO_3 are present in larger amounts in the stratosphere, but are present in the upper troposphere, and are indicators of stratospheric-tropospheric exchange. H2O and CFC11 have largest abundances in the troposphere, but are transported into the stratosphere, and are also useful indicators of stratospheric-tropospheric exchange. These species are expected to be the most sensitive to the affects of S/C jitter because of their strong gradients and large curvature in the lower stratosphere/upper troposphere. The focus of the discussion is specifically on the added random radiance error produced by S/C jitter and the subsequent potential impact on the scientific goals of the HIRDLS project.

The retrieval errors shown here were calculated using an estimate of mechanical disturbances at the HIRDLS baseplate arising from a number of sources including CHEM instruments and spacecraft solar array and reaction wheel assemblies. A power spectral density function defining the spacecraft disturbances was derived from data obtained from TRW (see HIRDLS technical memo TC-NCA-075). The HIRDLS line-of-sight (LOS) response to these disturbances was calculated using a model of the instrument transmissibility. The resultant LOS spectral response was converted to a time series of random LOS motions. These random motions were applied to radiance profiles (as a function of altitude), calculated for each of the HIRDLS channels, to generate time varying radiance signals. The radiance signals were then passed through a simulation of the instrument signal-processing chain to determine the radiometric measurement errors. Finally, the radiometric errors were combined with retrieval sensitivity matrices derived from the optimal estimation approach used for retrieving constituent concentrations. This formalism yields, among other things, an estimate of the random error in retrieved mixing ratios due to random measurement error.

1) Ozone (O_3):

Ozone distributions peak at approximately 10 ppmv in the stratosphere between 30 and 40 kilometers. This distribution drops off significantly in both the mesosphere and lower stratosphere to values less that 1 ppmv. In the upper troposphere, ozone values range between 50-200 ppbv. In most of the stratosphere (15-55kms) the total random error including the sum of the radiometric noise, the pointing error, and the S/C jitter is only a few percent. This amount will not impact any of the above mentioned science studies in this region. The additional impact of S/C jitter is not important in the mesosphere. However, in the upper troposphere and lower stratosphere (UT/LS), including the current estimates of jitter increases, the random noise given by the "radiometric noise plus pointing error" changes from less than 5% to values greater than 10% (See Table 1 and Fig. 1a.). This corresponds to an uncertainty due to random noise of approximately 10-30 ppbv in ozone. This additional random error could hinder the usefulness of the HIRDLS ozone data in the UT region, for instance in increasing the error of the estimated fluxes of ozone from the stratosphere into the troposphere. The size of such errors after allowing for data sampling and gridding has not yet been estimated. With the presence of a cloud, ozone retrievals are limited to lower altitudes a few km above the cloud-top as shown in Figure 1b (see discussion in Section 5.).

2) Water (H_2O):

In the upper troposphere, H_2O abundance ranges between 5-100 ppmv (increasing towards the surface). In the lower stratosphere, H_2O abundances reach a minimum of approximately 3 ppmv in the tropics and mid-latitudes at 18 and 15 kilometers, respectively. Water abundance increases in the stratosphere due to the oxidation of methane (CH_4) to approximately 6 ppmv in the upper stratosphere and lower mesosphere. The baseline "radiometric noise plus pointing error" is estimated to be less than 5% for most of the stratosphere (i.e. tropopause to 50 km). The additional random noise from S/C jitter is not important above the tropopause. The additional random noise from S/C jitter at or a few kilometers below the tropopause does enhance the total random noise, but in most cases the total noise is still below 5% (See Table1). This should not hamper the HIRDLS scientific goals.

3) Nitric Acid (HNO_3):

Nitric acid abundances peak in the lower stratosphere at approximately 20 kilometers (10 ppbv), decreasing too less than 1 ppbv by 40 kilometers. This peak in HNO_3 has a strong latitudinal dependence (increasing a few ppbv in the tropics to 5-10 ppbv at mid-to-high latitudes). In the upper troposphere, HNO_3 abundances range from 10-100 pptv, depending again on latitude and season. The baseline "radiometric noise plus pointing error" is estimated to be less than 5% between approximately 10-35 kilometers. The additional random error from S/C jitter is not important above 20 kilometers. Below 20 kilometers the increase in random noise from the estimated "current S/C jitter" under clear sky or no cloud assumptions is minimal, as shown in Figure 2a. However, when the presence of a cloud is included, the total random noise can increase from 5% (at 10km, no cloud) to greater than 15% (with jitter) (see Table 1, and Fig. 2b). This additional random noise from S/C jitter will make accurate retrievals of HNO_3 less valuable below 20 kilometers, however, even with this inaccuracy, HIRDLS global measurements would be a very important contribution to our current knowledge of HNO_3 abundance in this region. Again, this additional random error will increase the error of the estimated fluxes of HNO_3 from the troposphere into the stratosphere.

4) Chlorofluorocarbon – 11 ($CFCl_3$):

Chlorofluorocarbon-11 (CFC-11) decreases from the surface (>200pptv) too less than 1 pptv at 30 kilometers. The "radiometeric only" error is approximately less than 5% between 8-20 kilometers. When the "pointing error" contribution is included the error is between 5-10% between 10-20 kilometers. Above 15 kilometers, the additional random noise for S/C jitter is not important. Below 15 kilometers this additional random error can increase the total random error from 5-10% to 15-20% (for 2x current estimate of S/C disturbance).

5) Effects of clouds

The results described above were calculated for the absence of clouds. Similar calculations to those described above were made which included a thick cloud (emissivity of 0.9) at 11 km. As can be seen by a comparison of Figs. 1a and 1b, or 2a and 2b, the effect of the jitter is to "smear" the cloud-top, which results in larger errors than in the no-cloud case for a few kilometers above the cloud. This effectively obscures that region and eliminates the possibility of obtaining retrievals down to cloud-tops. For ozone, the region thus obscured appears to be about 2 km. Because of the smaller signals in the nitric acid channel, jitter eliminates about 4 km in sounding range above the cloud.

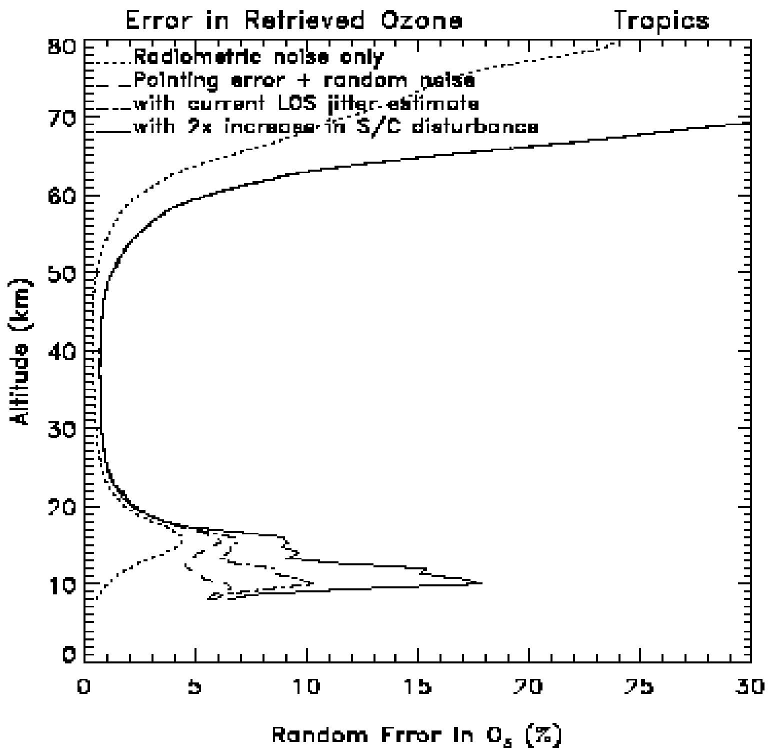
Summary

Jittering of the HIRDLS LOS due to larger than expected spacecraft disturbances results in larger radiance errors in the scientifically important lower stratospheric and upper tropospheric region, especially for nitric acid, ozone and CFC-11, and thus the inability to meet L1 requirements in the UT/LS. Perhaps more serious, when clouds are present, LOS jitter smears the radiometric signal in these channels over several km, precluding the retrieval of trace gas mixing ratios down to the cloud tops, and thereby losing several km of altitude coverage in the UT/LS.

Table 1: Random error analysis, results shown for current LOS jitter estimates.

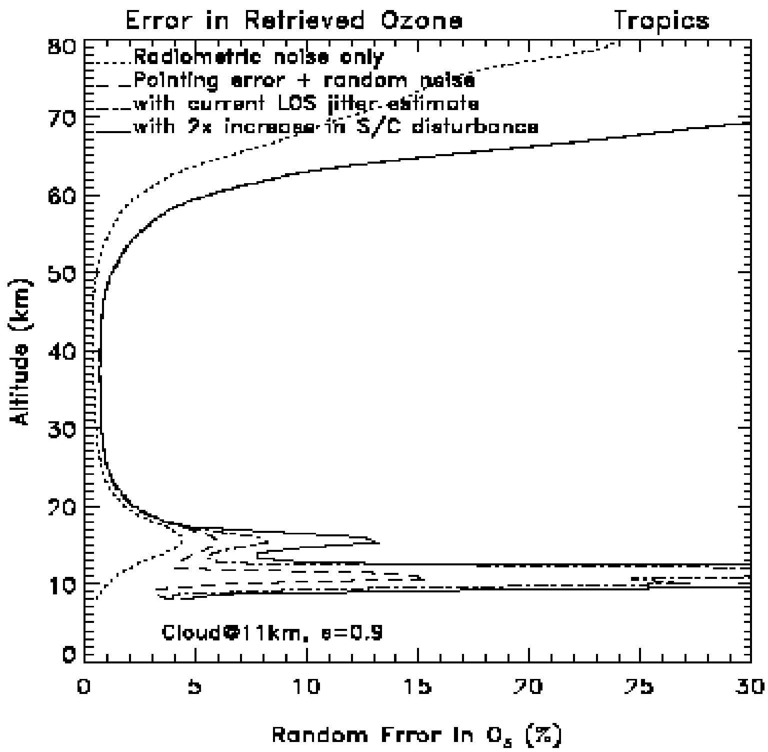
Species	Altitude km	Clouds e=0.9	Tropics Absolute MR	Tropics Error MR, %	Midlat Winter, Absolute MR	Midlat, Winter, Error MR, %
Ozone	10km	no	70 ppbv	7 ppbv 10%	300 ppbv	13 ppbv 4 %
	10km	yes	70 ppbv	20 ppbv 30%	300 ppbv	30 ppbv 10%
	12 km	no	100 ppbv	8 ppbv 9%	600 ppbv	8 ppbv 1%
	12 km	yes	100 ppbv	30 ppbv 30%	600 ppbv	30 ppbv 5%
	14km	no	125 ppbv	8 ppbv 6%	800 ppbv	10 ppbv 1%
	14 km	yes	125 ppbv	7 ppbv 6%	800 ppbv	10 ppbv 1%
	16km	no	200 ppbv	14 ppbv 7%	1100 ppbv	15 ppbv 1.5%
	30km	no	9000 ppbv	65 ppbv 1%	6000 ppbv	55 ppbv 1%
	70km	no	250 ppbv	80 ppbv 30%	300 ppbv	120 ppbv 40%
HNO_3	10km	no	180 pptv	30 pptv 17%	180 pptv	15 pptv 8%
	10km	yes	180 pptv	270 pptv 150%	180 pptv	170 ppt 90%
	12 km	no	250 pptv	20 pptv 9%	250 pptv	10 pptv 4%
	12 km	yes	250 pptv	350 pptv 140%	250 pptv	270 110%
	14 km	no	330 pptv	13 pptv 4%	330 pptv	10 pptv 3%

	14 km	yes	330 pptv	22 pptv 7%	330 pptv	22 pptv 7%
	20 km	no	4200 pptv	85 ppt 2%	4200 pptv	85 ppt 2%
	30km	no	3650 pptv	115 pptv 3%	3650 pptv	120 pptv 3%
H_2O	13km	no	5300 ppbv	300 ppbv 6%	4900 ppbv	70 ppbv 1.5%
	16km	no	3000 ppbv	190 ppbv 6.5%	4600 ppbv	65 ppbv 1.5%
	30km	no	3900 ppbv	100 ppbv 2.5%	4700 ppbv	200 ppbv 4%
	70km	no	4000 ppbv	1500 ppbv 38%	3200 ppbv	1250 ppbv 40%
CFC11	13km	no	137 pptv	11 pptv 8%	137 pptv	8 pptv 6%
	16km	no	125 pptv	8 pptv 6%	125 pptv	8 pptv 7%
	25km	No	22 pptv	3.4 pptv 15%	22 pptv	3.7 pptv 14%



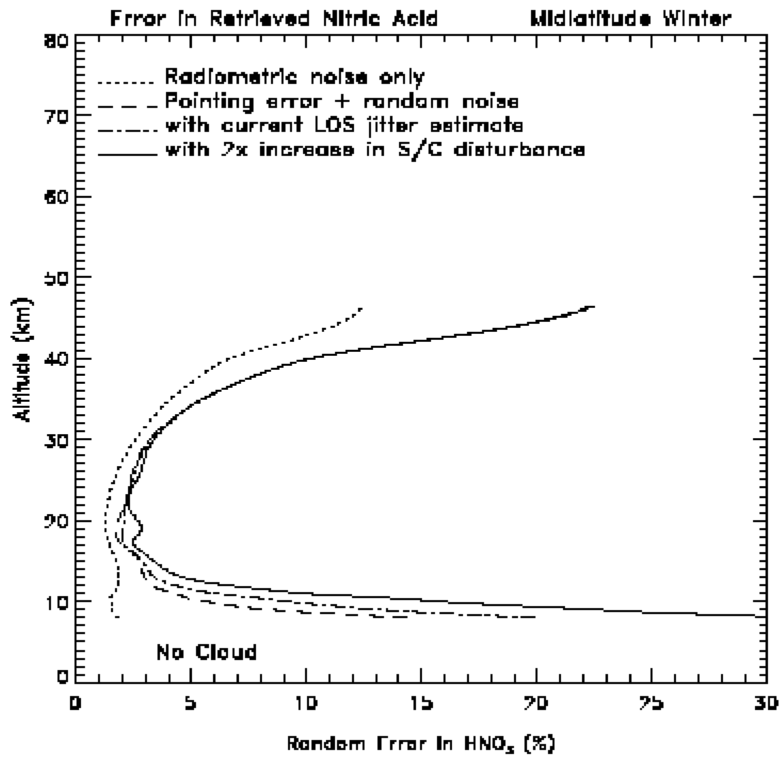
Error in Retrieved Ozone
Tropics
Radiometric noise only
Pointing error + random noise
with current LOS jitter estimate
with 2x increase in S/C disturbance
Altitude (km)
80
70
60
50
40
30
20
10
0
0
5
10
15
20
25
30
Random Error in O_3 (%)

Figure 1a.



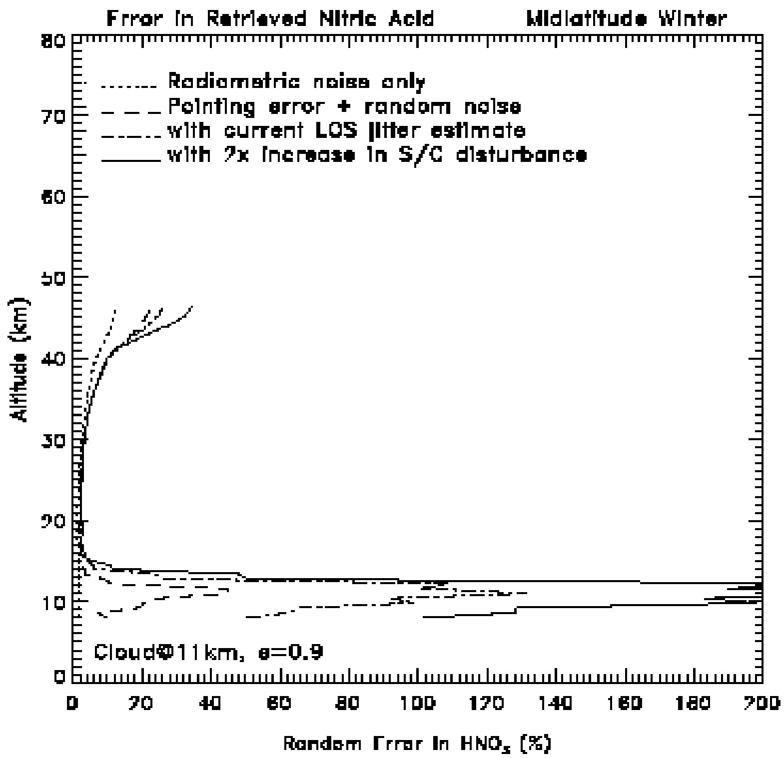
Error in Retrieved Ozone
Tropics
Radiometric noise only
Pointing error + random noise
with current LOS jitter estimate
with 2x increase in S/C disturbance
Cloud@11km, e=0.9
Altitude (km)
Random Error in O3 (%)
0
10
20
30
40
50
60
70
80
0
5
10
15
20
25
30

Figure 1b.



Error in Retrieved Nitric Acid
Midlatitude Winter
Radiometric noise only
Pointing error + random noise
with current LOS jitter estimate
with 2x increase in S/C disturbance
No Cloud
Altitude (km)
Random Error in HNO_3 (%)

Figure 2a.



Error in Retrieved Nitric Acid
Midlatitude Winter
Radiometric noise only
Pointing error + random noise
with current LOS jitter estimate
with 2x increase in S/C disturbance
Altitude (km)
Cloud@11km, e=0.9
Random Error in HNO3 (%)
0
20
40
60
80
100
120
140
160
180
200
10
30
50
70

Figure 2b.

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 42

Originator: Ed Bielecki
Phone: 301-286-4649
Organization: Boeing/GSFC/424

Assigned to: M. Dials
RO: UCB
Due Date: 99-06-30

Category: ELECTRICAL
Title:
Date Closed:
Residual Risk:

Action Requested:
Recommend not impacting or otherwise negatively affecting the design of the Power Control Unit (PCU) because of instrument limitations on resources (weight and power).

Supporting Rationale:
No matter how sophisticated or complicated the instrument design, the unsophisticated, basic power supply must perform to specification. Cutting corners in this area now can create subsequent problems (weight reduction > thermal consideration).

Project Response:
See response to RFA #47.

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 43

Originator: Ed Bielecki
Phone: 301-286-4649
Organization: Boeing/GSFC/424

Assigned to: B . Taylor
RO: UCB
Due Date: 99-06-18

Category: SOFTWARE
Title:
Date Closed:
Residual Risk:

Action Requested:
Re-evaluate the present HIRDLS fault management philosophy.

Supporting Rationale:
In light of the requirement for 24 hour autonomous operation and in the interest of instrument safety, Lockheed needs to revisit their present fault-management plan. Example: Simply processing in response to a 'watchdog timer' timeout without consideration of instrument configuration and safety seems rather simplistic and potentially detrimental to instrument performance.

Project Response:
Our original Fault Management Philosophy and actions list is documented in TC_LOC_212, modifications were made to the actions list from above document during the HIRDLS Flight Software Meeting held from 30 March through 3 April, 1998, at Oxford (MV-LOC-309). Due to experience gained through Flight Software development at Lockheed further discussion/modifications are required to our Philosophy/actions list.

A meeting has been arranged for June 14 1999 at Oxford as part of our tri-monthly tech meets. Fault management philosophy will be discussed and agreed during this meeting.
A further meeting will be held at LMATC late June/early July to finalize implementation details. The revised fault management software requirements and actions will be documented in the IPU Software Requirements Specification Document (SW-LOC-108). Operational command and telemetry aspects will be documented in Section 4, Vol. I of SP-HIR-103, the HIRDLS Command & Telemetry Handbook (C&TH).

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 44

Originator: Tony Miller
Phone: 301-286-4444
Organization: NASA/GSFC/565

Assigned to: S. Richard
RO: LMMS
Due Date: Plan by 99-06-18

Category: ELECTRICAL
Title:
Date Closed:
Residual Risk:

Action Requested:
Provide a 'HIRDLS Harness Development and Certification Plan' for review and acceptance by the EOS Chemistry project.

Supporting Rationale:
The harness within the HIRDLS instrument will distribute power, commands, telemetry and raw scientific analog data (prior to digital conversion). The harness can contribute to contamination, vibration, and weight of the instrument. Cleanliness cannot be overstressed in the HIRDLS development due to the fact that there are optics within the instrument. The wire is fabricated on machines that use lubricants; therefore, specifications must be reviewed to verify that the wire will meet a certain level of cleanliness before fabrication. Harness connectors and shielding contribute to EMI control. Harness weight and tiedowns will effect the vibration environment. These items must be addressed in a formal plan. Goddard Space Flight Center stresses the need for a reliable harness built to withstand the EMI, cleanliness, vibration and flight environments. The harne! ss must not contribute to the degradation of the instrument performance in any of those areas. The harness must withstand the rigors of handling during fabrication certification and integration. The harness plan must adhere to existing GSFC NHB guidelines in all applicable areas.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 45

Originator: Paul Brook, Ray Turner
Phone: (44) 1252 393267, (44) 1235 446433
Organization: NERC, RAL

Assigned to: J. Loh
RO: UCB
Due Date: 99-06-30

Category: SCHEDULE
Title:
Date Closed:
Residual Risk:

Action Requested:
1) The schedules presented at CDR need to be reviewed at subsystem level and more accurately coordinated at system level. 2) No slack exists in the program. What can be planned as a contingency (e.g. truncation of calibration?)

Supporting Rationale:
Examples: a)TSS schedule shown to start in April 1999 in subsystem review but in December 1998 in Master schedule. Despite this, the end point is consistent. b) The IFC schedule shows significant overlap between the EM and PFM processes. The dependence of PFM on EM build and test is not clear. c) The PSS manager was noted to be 'surprised' by the presented schedule of his own system. d) Master schedule and I&T schedule vary by three weeks on delivery of the EM to Oxford for cals. e) Oxford schedule differs from others by two weeks on delivery of PFM to Oxford for cals.

Project Response:
Since CDR, the project has had two meetings to review the schedule in detail at the subsystem level and to coordinate the subsystem schedules at the system level. HIRDLS now has a consolidated schedule which has been reviewed by all the HIRDLS organizations. This consolidated schedule is being used by all organizations and formal monthly updates are required from all subsystems into this schedule.

Obtaining contingency at the program level has also been discussed at these meetings. We currently have about one month of contingency. Options, such as putting in a second I&T team to run two shifts, are being evaluated to get back more contingency.

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 46

Originator: Kirk Rhee, Paul Brook, Steve Scott
Phone: 301-286-7168, (44) 1252 393267, 301-286-2846
Organization: NASA/GSFC/424, NERC, NASA/GSFC/730

Assigned to: D. Woodard
RO: UCB
Due Date: 99-06-30

Category: POWER
Title:
Date Closed:
Residual Risk:

Action Requested:
1) Perform thorough instrument-level systems engineering review and reallocation of power budgets. 2) As part of the above effort, delineate peak power for all phases of mission: launch, pre and post deployment, in-flight calibration, and operation. 3) Define the design margin allowed for the PSS to provide the system level power allocations.

Supporting Rationale:
1) Subsystems are going to extraordinary measures to meet power allocations (perhaps having an overall deleterious effect on overall systems reliability) when these potentially problematic redesigns could be prevented by a rational reallocation of power by Instrument Systems Engineering. Additionally, there appeared to be a number of discrepancies between system level power budgets and PSS requirements (e.g. (a) IPU peak power is shown as 46W on the Q bus and 42W on the regulated bus. The system level figure is 42W. (b) SPU shows a peak power of 20.4W at system level and 29.4W in the PSS. (c) TEU shows 49.2 (peak), 20 (ave.) at system level and 32.1 (peak), 14.9 (ave.) at the PSS. 2) Current power budget table with Peak power is confusing since the subsystems don't match the total. Also, the power numbers used in the thermal analysis don't seem to agree with this Power Table.

Project Response:
System Engineering completed review of power budget. A request will be submitted to GSFC for additional power.

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: **47**

Originator: Steve Scott
Phone: 301-286-2846
Organization: NASA/GSFC/730

Assigned to: Dials/Arter
RO: UCB
Due Date: 99-06-30

Category: SYSTEMS ENG.
Title:
Date Closed:
Residual Risk:

Action Requested:
Perform thorough instrument-level systems engineering review and reallocation of mass budgets.

Supporting Rationale:
Subsystems are going to extraordinary measures to meet mass allocations (perhaps having an overall deleterious effect on overall systems reliability) when these potentially problematic redesigns could be prevented by a rational reallocation of mass by Instrument Systems Engineering.

Project Response:
The HIRDLS instrument mass properties are monitored and controlled at the program office (University of Colorado). The instrument integrator is required to provide a monthly mass properties report to the program office. Mass is allocated to the subsystems via the Instrument Technical Specification (ITS). Each Responsible Organization (RO) is responsible for allocating and managing the mass within their subsystem. New mass allocation requests are reviewed and approved by the HIRDLS Mass Properties Control Board (MPCB). Members of the MPCB are:

Mike Dials – HIRDLS Technical Manager (Chair)
John Whitney – HIRDLS Systems Engineer
Joanne Loh – HIRDLS Program Manager
Nigel Morris – UK HIRDLS Program Manager
Steve Richard – Lockheed HIRDLS Program Manager
Neil Martin – NASA HIRDLS Instrument Manager

A request for a change in the mass allocation can originate from the program office or from any RO. Once a mass allocation change has been approved by the MPCB the ITS is revised.

Although the HIRDLS instrument as a whole is comfortably within the 200kg NASA allocation, some areas of the instrument are more sensitive to mass increases than others. Two of these sensitive areas are the “sprung” mass on the internal isolators and the mass on the electronics shelf. The Power Subsystem (PSS), which is on the electronics shelf, designers have been working to reduce the PSS mass to the allocation for two reasons:

1) The lowest stress margins for the instrument are at the electronics shelf to mid-wall connection. In fact there was a failure of this joint on the first qualification vibration attempt. (MMS has modified the design and there are now adequate stress margins.)
2) The UK Program manager, who is responsible for both the STH and the PSS, was concerned that PSS mass growth could require additional MMS modeling effort and possibly STH requalification, and therefore added UK cost.

Since the CDR MMS has reviewed and approved a mass increase of the PSS of an additional 1kg. The MPCB has met and approved a change of the PSS mass allocation from 8.5kg to 9.5kg.

Project:	Earth Observing System
Spacecraft(SC/GS/LV):	CHEMISTRY
Instrument:	HIRDLS
Review:	CDR
Date:	Apr. 27-29, 1999

Request for Action

Number: 48

Originator: Greg Greer
Phone: 301-286-7295
Organization:

Assigned to: All ROs
RO:
Due Date: Plan by 99-06-18

Category: THERMAL
Title:
Date Closed:
Residual Risk:

Action Requested:
Revamp, rework and resubmit the responses provided per PDR RFA #013 which asks: 'Verify that all system electronics will have a detailed thermal analysis to the circuit card and/or component level. [Note: All electronics boxes TCS reports could not be found, such as CCU, EEA, PCU, etc. Please reissue all to the below guidelines.]

Supporting Rationale:
The response promised results by CDR. Upon review of those box level thermal reports provided (such as IPU [TC-LOC-371], TEU [TC-LOC-400], SPU [TC-LOC-372] ∑), a number of improvements are requested: (1) reference all temps in °C; (2) reference document # on each page; (3) report predicts for all components, not just averages (where possible); (4) always report tabulated predicts adjacent to temperature limits and DT margin resulting; (5) use derated junction temperatures instead of -55°C/125°C.

Project Response:
Please reference TC-LOC-416A (ITAR sensitive)